

NATIONAL BUREAU OF STANDARDS REPORT

4870

DESIGN AND CALIBRATION
OF
LUMINANCE STANDARDS
FOR
THE THREE COLOR PHOSPHORS
USED IN
COLOR TELEVISION TUBES

by

Velma I. Burns



**U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS**

U. S. DEPARTMENT OF COMMERCE

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NATIONAL BUREAU OF STANDARDS

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● Office of Basic Instrumentation

● Office of Weights and Measures

BOULDER, COLORADO

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Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services.

Radio Propagation Engineering. Frequency Utilization Research. Tropospheric Propagation Research.

Radio Standards. High Frequency Standards Branch: High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Microwave Standards Branch: Extreme High Frequency and Noise. Microwave Frequency and Spectroscopy. Microwave Circuit Standards.

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NBS PROJECT

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October, 1956

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Prepared for

Joint Electron Tube Engineering Council

JTC-6.3 Subcommittee



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NATIONAL BUREAU OF STANDARDS

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Report on the Design and Calibration
of
Luminance Standards
for
The Three Color Phosphors
Used in Color Television Tubes

1. SCOPE

This report describes the design and the calibration of luminance standards for measuring the luminance of the three color phosphors used in color television tubes.

2. COMPLETE LUMINANCE STANDARD

A complete set of three luminance standards consists of: (1) a 500-watt projection lamp standard, (2) a 3-inch-square, red-glass filter bound to a 3-inch-square diffusing glass, (3) a 3-inch-square green-glass filter and diffusing glass, (4) a 3-inch-square, blue filter and diffusing glass. The relative spectral energies of the standards are designed to match approximately the relative spectral energies emitted by the red, green, and blue phosphors used in color television tubes. The relative spectral energies of the phosphors were supplied by the Joint Electron Tube Engineering Council, Committee on Cathode Ray Tubes JTC-6, (see letter of January 27, 1955 to Dr. D. B. Judd, signed by Joseph P. Foltz, Secretary.) The relative spectral energies of the phosphors and of the luminance standards are shown on the accompanying curve sheet.

2.1 LAMP

A 500-watt projection lamp, calibrated for luminous intensity in a specified direction when operating at a color temperature of 2916°K is supplied with each standard. Each lamp is designated by an NBS number etched on the bulb.

2.2 DIFFUSING GLASS

Each luminance standard is supplied with a 3-inch square of flashed opal glass bound to a filter of the appropriate color for diffusing the light from the standard lamp. It was determined that when the lamp operates at 2916°K the color temperature of the light transmitted through the opal glass is 2854°K , CIE Standard Source A.

2.3 COLOR FILTERS

2.3.1 Blue Filter. The blue filter has two components, an instrument blue green glass, Corning glass code 4784, 6.0 mm thick, and a signal blue glass, Corning glass code 5562, 2.0 mm thick. The two glasses were bound together with a flashed opal diffusing glass.

2.3.2 Green Filter. The green filter consists of a sextant green glass, Corning glass code 4010, 4.7 mm thick, bound with a flashed opal diffusing glass.

2.3.3 Red Filter. The red filter consists of an H.R. traffic red glass, Corning glass code 2418, 3.0 mm thick and an instrument blue green glass, Corning glass code 4784, 1 mm thick, bound together with a flashed opal glass.

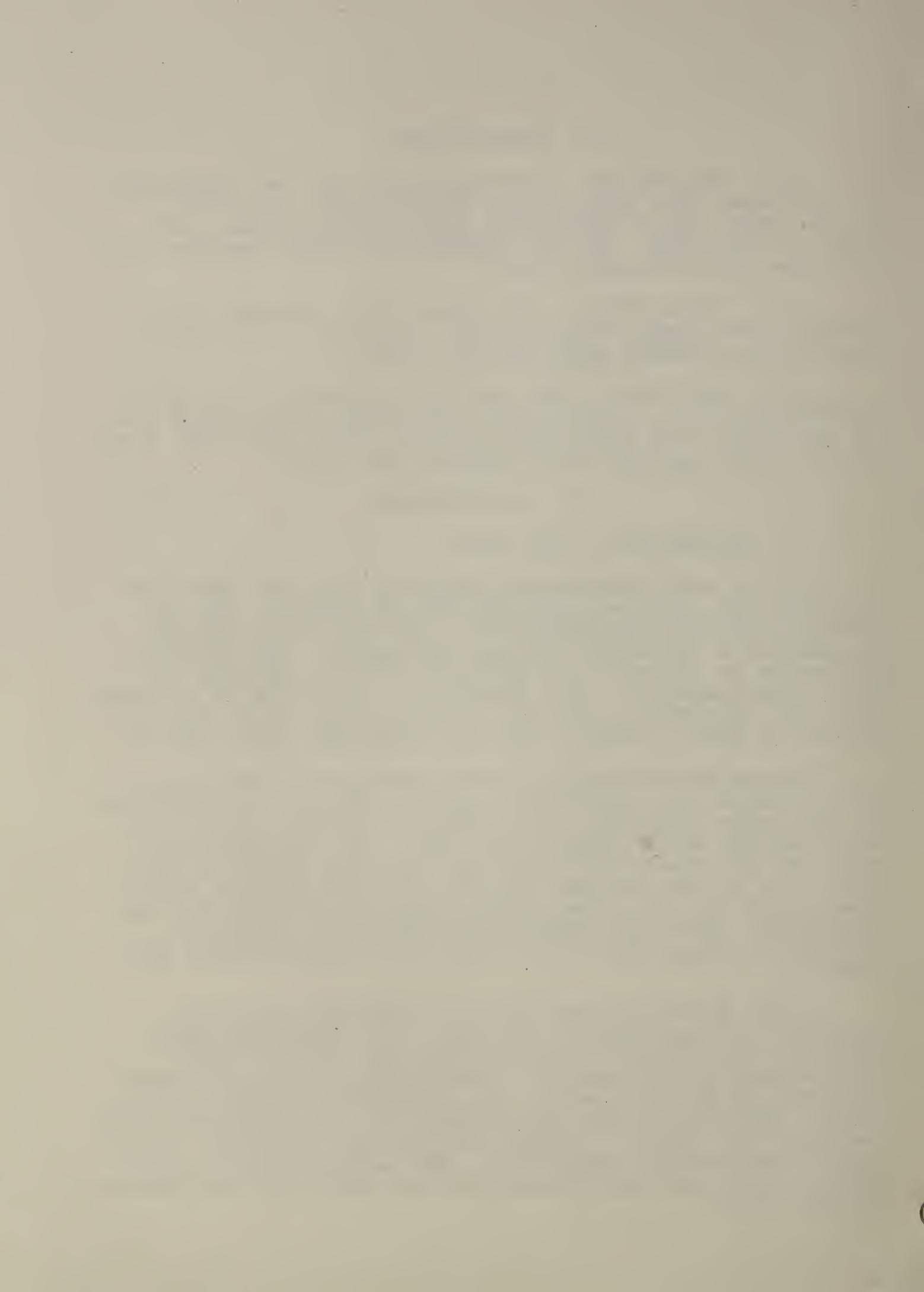
3. CALIBRATIONS

3.1 Calibration of the Lamps.

For the color temperature determinations the lamps were compared with standard lamps NBS1924 and NBS1926. For the luminous intensity determinations, the lamps were measured by means of a calibrated physical photometer. The physical photometer is calibrated at periodic intervals against the basic lamp standards. This photometer, consisting of a thermopile and luminosity filter is a modified form of the one described in NBS J. Research 27, 217 (September, 1941) RP1415.

For the determination of color temperature, the lamps were measured by a substitution method. For the determination of both color temperature and luminous intensity, the lamps were measured while burning base down. The orientation was such that the plane containing the two lines etched on opposite sides of the bulb was parallel to the photometer axis, the line having the etched circle being turned away from the photometer. The color temperature comparisons were made visually by using the $9 \times 13^\circ$ field of a Lummer-Brodhun photometer.

In the intensity measurements a diaphragm having an opening 2 1/2 centimeters high and 9 1/2 centimeters wide, centered with respect to the filament and located 4 1/2 centimeters from the center of the socket, was placed between the lamp and the photometer. The photometric distance was 1 meter. With the voltage held constant at the designated value, readings were taken of current and luminous intensity. Three sets of measurements were taken. The results given in individual reports accompanying each set of standards are averages of the 3 sets.



3.2 CALIBRATIONS OF THE FILTERS

One set of filters to be used as a master set was first calibrated. The master set is being retained at this Bureau for calibrating extra filters when required or for recalibrating those which are now being supplied. The luminous transmittances for the assembled color components of each of the three filters of the master set were measured. Measurements were made by using the physical photometer and also the General Electric recording spectrophotometer.

The luminance of each opal glass component was measured in footlamberts produced on the nonflashed side per footcandle incident on the flashed side. This was determined by comparing it with a group of four calibrated squares of similar opal glass.

The luminance of each of the three completed filters of the master set was then computed, taking into account multiple reflections. The luminance of the filters in the remaining sets were compared with those of the master set. For all measurements a diaphragm 2 1/4 inches in diameter was placed against the standard on the opal-glass side with the opal-glass side facing the lamp.

4. INVESTIGATIONS

4.1 Validity of the Inverse Square Law. It was necessary to determine if the inverse square law could be used for distances necessary to produce 50, 20, and 2 footlamberts on the standards. Since the blue filter has the lowest transmittance (that is, it requires the shortest distance between lamp and filter) it was used for the investigation. The blue filter was placed on a photometer bar at the proper distances from the filament of a standard lamp so as to produce 50, 20, and 2 footlamberts. The luminance of the filter was then measured photoelectrically. The distance between the opal glass surface of the filter and the filament of the standard lamp was measured by using a telescope to align the filament of the lamp and the opal glass surface respectively with the markings on a meter scale. The inverse square law was found to hold for this standard at the distance required.

4.2 Effect of Change of Temperature on the Filter. All measurements were made in a room where the ambient temperature was 25°C. The filters in use, however, are heated by radiant energy from the standard lamp. In order to determine the effect of this heating on the luminance produced, one filter of each color was placed successively on the photometer bar at the proper distances to produce 50, 20, and 2 footlamberts and its luminance was measured at intervals over a period of twenty minutes. The decrease in luminance in the case of each filter is a curve represented approximately by the values given in the following table. The heating effect when 2 footlamberts are used was found to be negligible.

Filter	Luminance (footlamberts)	Decrease in Luminance with Time After Filter is Exposed to Light
Blue	50	0.25%/min for first 11 min. .16%/min for next 9 min.
	20	0.19%/min for first 8 min. .15%/min for next 12 min.
Green	50	0.39%/min for first 8 min. .22%/min for next 12 min.
	20	0.20%/min for first 8 min. .06%/min for next 12 min.
Red	50	0.83%/min for first 7 min. .44%/min for next 6 min. .23%/min for next 7 min.
	20	0.55%/min for first 4 min .31%/min for next 6 min. .15%/min for next 10 min.

5. USE OF THE STANDARDS

5.1 The Standard Lamp. The standard lamp should be aligned and diaphragmed as described for calibration. The purpose of the diaphragm is to keep from the opal-glass receiving surface the light that is reflected from the top and bottom of the bulb and from the stem. The dimensions of the diaphragm need not be duplicated exactly; the width of the opening should be wider than the lamp bulb; the height should be sufficiently greater than that of the filament so that slight vertical displacement will not obstruct light coming directly from the filament, but small enough to exclude the reflections mentioned above. The distance of the diaphragm from the center of the socket is not critical.

The lamp should be turned on and allowed to operate at the proper voltage until steady conditions are reached before measurements are made. This requires about 5 minutes for 500-watt lamps. The filters should be shielded from the radiant energy from the lamp during the warm-up time.

Care should be taken to measure the voltage across the lamp accurately; potential leads must be connected as close as possible to the lamp base. A potentiometer or a good quality calibrated meter (accurate to within 1/10 percent) should be used.

5.2 Filters. The standards were calibrated with a diaphragm 2 1/4 inches in diameter placed against the filter on the opal-glass side. This diaphragm should be duplicated when the standards are used. The transmittances of the filters decrease when the filters are heated. The filter should be shielded from the lamp during the warm-up time of the lamp and the luminance values read may be corrected by using the data given in the table above. This is particularly necessary when the red filter is being used.

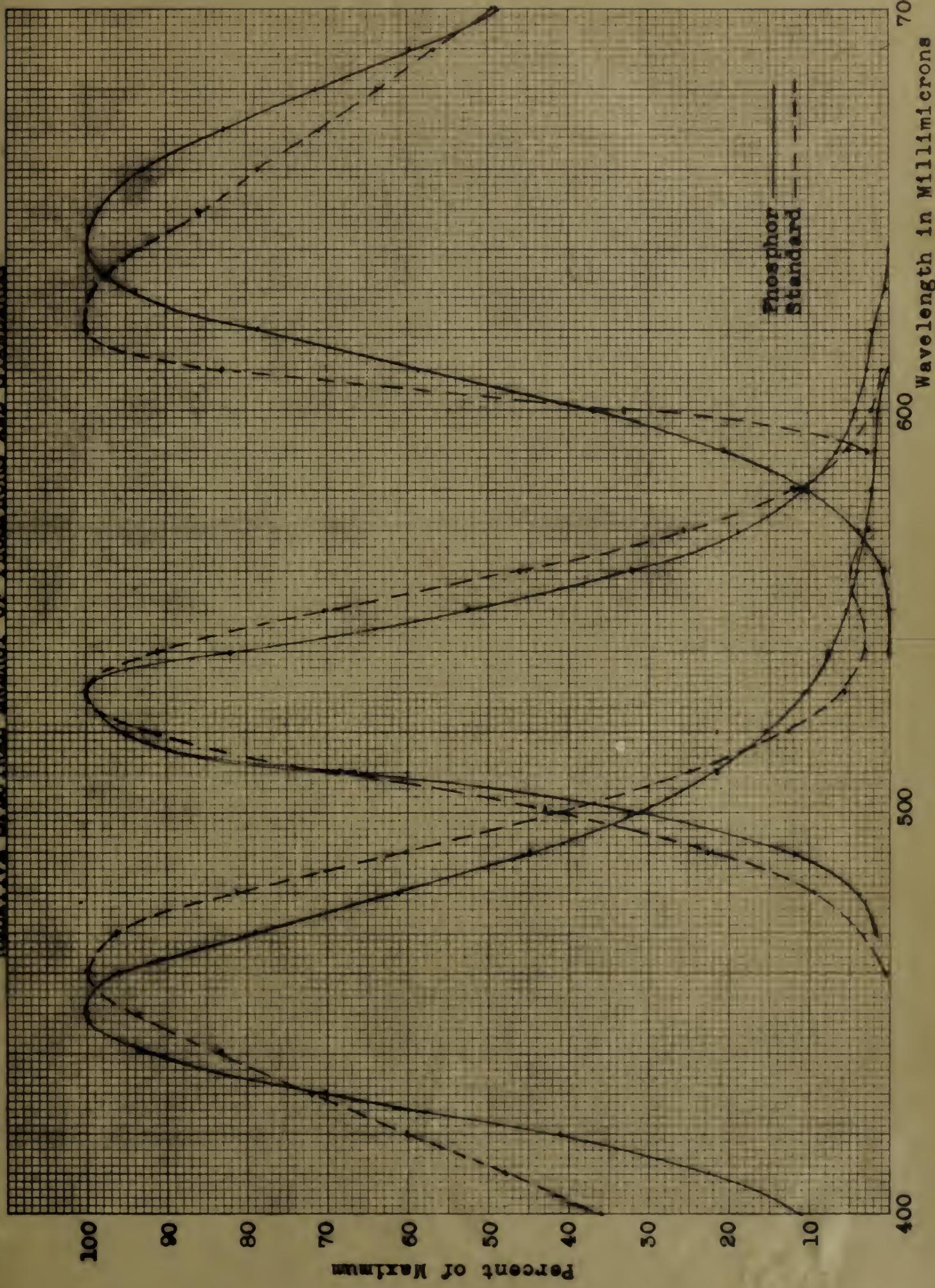
5.3 Distance Between Lamp and Filter. This distance must be carefully measured, particularly for the short distances. It may be done by using a telescope to align first the lamp filament and then the surface of the opal glass with the markings on a meter scale placed near the standard as set up to be used. Distances required to produce 50, 20, and 2 footlamberts will be given in individual reports which accompany each set of standards. Luminance values less than 50 footlamberts may be computed for other distances by using the inverse square law.

5.4 Diaphragming of Receptor and Distance from Standard.

The receptor must be equipped with an aperture diaphragm and both receptor and diaphragm positioned on the axis at such a distance that, when viewed from any point on the receptor surface, the aperture is completely filled by the standard, and no ray strikes the receptor at more than 15 degrees from the axis.

For example, if the receptor diaphragm is one inch in diameter, and the sensitive surface of the receptor is 1 1/2 inches in diameter, the receptor surface must be fixed at a distance greater than 5 inches from the diaphragm, and the receptor diaphragm must be placed not more than 3 inches from the opal face of the standard.

RELATIVE SPECTRAL ENERGY OF PHOSPHORS AND STANDARDS



THE NATIONAL BUREAU OF STANDARDS

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The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

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Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.



COMPUTATION OF

EFFECTIVE INTENSITY

Choice of
Time Interval

$$I_{EFF} = \frac{\int_{t_1}^{t_2} I dt}{.2 + (t_2 - t_1)}$$

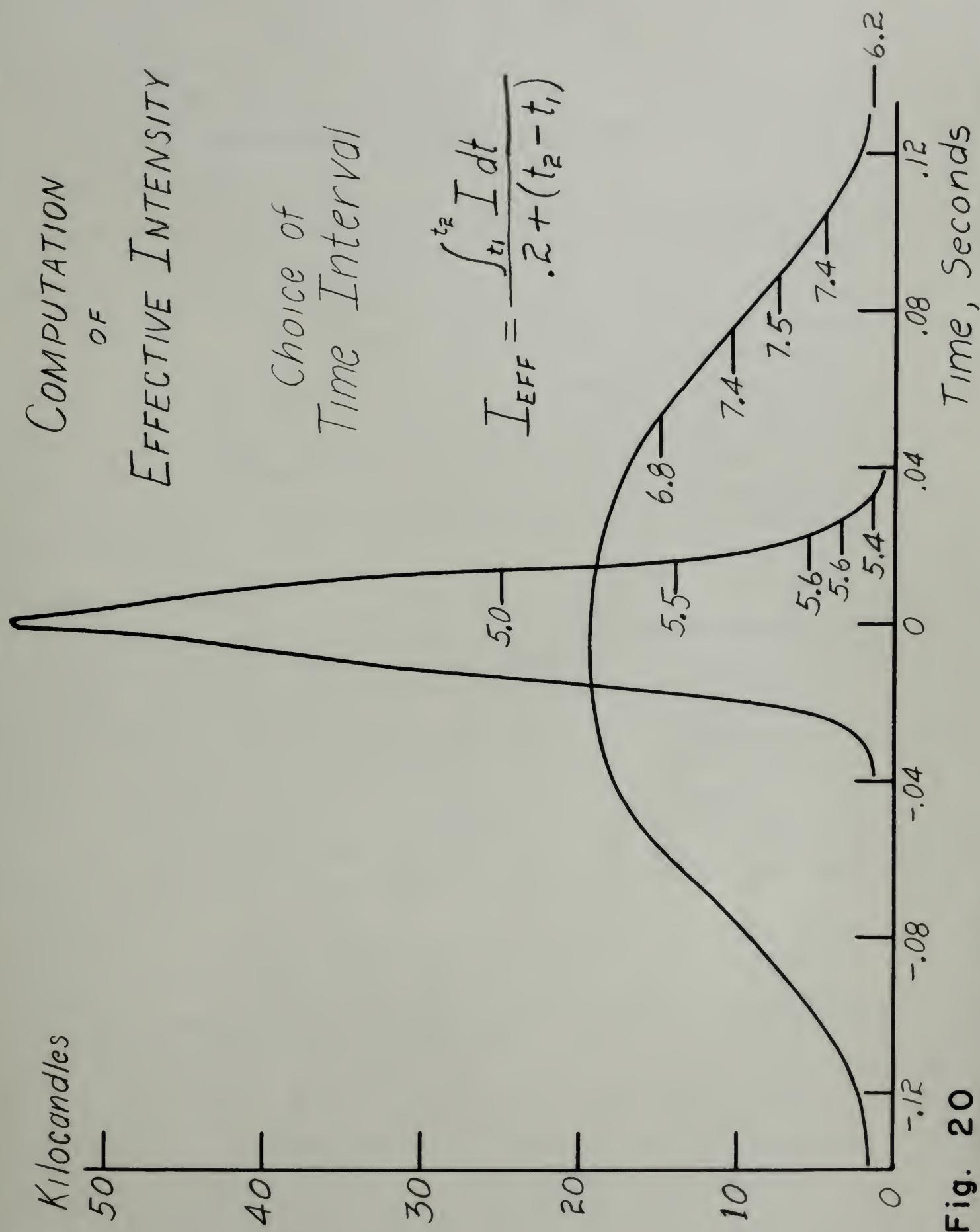


Fig. 20

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